true magnetic poles has not always been attended to with sufficient care, and this is partly to be accounted for by the considerable and often preponderating influence of these maximum points on the several magnetic elements. A consequent doubt was for a long time entertained respecting the number of the magnetic poles. Halley, from a careful study of an extensive series of declination observations, made partly by himself in 1698-9, was led to the conclusion that the earth has four magnetic poles. The same opinion has been most ably advocated within our own days by Prof. Hansteen of Christiana, who had previously collected together a vast mass of observations of the declination, dip, and horizontal force. But the interesting series of results which Hansteen has brought forward in support of his view, are most readily explained by the evident changes that have taken place in the magnetic state of the region of maximum intensity situated in Siberia, where Hansteen himself specially observed. The Northern regions, where the magnetic force is greatest, abound in ferruginous strata, and there too the intensity of the cold far exceeds anything that is experienced in other lands on the same parallel of latitude. These regions may therefore not only be charged with a most abundant supply of permanent magnetism, but they may also be affected to a very considerable degree by atmospheric changes, and by those electric currents that are continually passing to and fro in the upper crust of the earth, and are doubtless producing very important changes in the subpermanent magnetism of certain layers of softer ferruginous matter. Whatever may be the nature of terrestrial magnetism, we cannot ignore the great influence exercised on its distribution by what may be termed local magnetism, the magnetism of volcanic formations, of mountain chains, of ferruginous beds; some harder than others and therefore less subject to magnetic influence, but retaining its effects the longer; some more affected by the extremes of heat and cold, and hence exposed to more rapid and radical changes in their magnetic condition.

But the question of the number of magnetic poles is leading us to another point of scarcely less importance, viz., the investigation of the changes that take place in the magnetism of the globe. The first point of inquiry is whether terrestrial magnetism as a whole is subject to continual change, and if so, are these changes periodical? Do they move in cycles? Do they follow any fixed laws that may lead to a knowledge of their causes?

The difficulty in answering these questions arises mainly from the irregular distribution of the points of maximum intensity; but, granting that we meet with numerous exceptional cases, which no doubt will finally be discovered to depend on local influences, we can trace a very regular and periodic change in all the magnetic elements.

The first accurate observations that have come down to us are those of the declination, or variation of the compass, taken in Paris in 1541, when the needle pointed 8° to the east of the astronomical meridian. From that period the easternly deviations gradually increased, until it attained a maximum value of 11° 30' in 1580, when it returned slowly on its path and vanished in the year 1660, Paris being then on the curve of "no variation." Pursuing its westernly course, the needle pointed more and more west of north each year, and only reached its greatest western elongation of about 23° in 1814. The needle is at present returning towards the east, at the yearly rate of about 9'·5, and actually points rather less than 17° west of north. The variations of the declination at London have followed much the same order as those at Paris, nor has there been any great difference in the extent.

The dip observations have unfortunately not been carried on so continuously during such a long series of years, and in consequence the secular variation of this element is less well determined than that of the declination. With the exception of a single observation by Norman in 1576, who found the inclination of the needle at London to be 71° 50', we have scarcely any reliable data previous to 1720, when the dip had increased in London to 74° 42'. Since the latter epoch this element has always continued to decrease, being 70° 35' in 1800, and now less than 68°, with an annual diminution of about 2'·5.

Of the secular variation of the intensity we know even less than of that of the dip, since the first observations date only as far back as the end of the last century; and we have no less an authority than that of Sir Edward Sabine for the statement, that "at commencement of the present century the bare fact of there being any difference whatsoever in the intensity of the magnetic force in different parts of the earth was unattested by a single published observation." The results, however, of modern research supply us with the important fact that the horizontal component of the intensity is at present rapidly increasing, its yearly rate of change being one 600th of its total value.

Now each and all of these gradual variations in the several elements of the earth's magnetism force upon us the conclusion that the magnetic pole must be endued with a motion of rotation in a more or less circular path around the pole of the earth's axis. The results of such a rotation apparent to an observer situated for example in England will be easily understood if we consider for a moment the similar movement of any of the inferior planets in its orbit round the sun as viewed from the earth. Take Venus, for instance, which is the most conspicuous of the planets. At one time it may be seen moving away from the sun towards the east, when it is called the evening star, since i sets later than the sun. This outward movement continues for a time, until the planet reaches the point of its maximum elongation; it then returns towards the sun, and after a time becomes lost to sight in the brilliancy of the solar rays, or on very rare occasions is visible in transit over the solar disc, as it will be for the first time this century in 1874, and again in 1882. Having passed the sun, Venus becomes the morning star, rising earlier and earlier until it has attained its greatest western elongation, when it again returns towards the sun. An analogous movement of the magnetic pole around the geographic pole has been clearly indicated by the secular variations of the declination, dip, and horizontal force. At the middle of the 16th century the bearings of the needle which would lead us to the magnetic pole were some 10° east of north. As time went on this deviation diminished, whilst the dip increased, showing that the magnetic pole was approaching us, as it got nearer and nearer to the meridian. About the middle of the 17th century, or rather somewhat later, the magnetic pole crossed our meridian, which thus for the moment partly coincided with the "line of no variation." From that time the needle has always pointed west, the western declination increasing more and more until the pole reached its maximum elongation in 1815. During this period there was a gradual decrease in the dip, manifesting a recession of the pole, and this has continued steadily, though with diminished acceleration, ever since the needle commenced its backward journey towards the geographic meridian. The present secular increase of the horizontal force also shows that the pole is receding, and that it will cross our meridian next on the further side of the geographic pole. This will take place, according to the calculation of M. Quetelet, director of the Brussels Observatory, about the year 1940, and thus a complete revolution of the magnetic pole will occupy a period of some 560 years. Other physicists make this period longer. Local magnetism must of course interfere greatly with the position of the pole, and with its velocity of revolution, but this disturbing cause will affect still more the movements or form of the "curve of no variation."

This rotation of the magnetic pole round the extremity of the earth's axis bears so striking a resemblance to the motion of the pole of the heavens round the ecliptic, that we are led at once to inquire if anything can be detected in the magnetic rotation that corresponds with the inequalities in the precession of the earth's axis, with the nutation caused by the action of the sun and moon. Are there, in other words, any annual, semi-annual, or monthly inequalities? The observations of the declination, taken during a series of years, and grouped together according to months, led to a variety of conclusions respecting the influence of the sun on the deflection of the needle. Arago agreed with Cassini in placing the sun in the vernal equinox at the maximum western variation, and in the summer solstice at the minimum; whilst Bowditch, in America, and Beaufoy, in England, both found that a maximum occurred in August and a minimum in December, though a second maximum and minimum were placed by each in different seasons. The fact of some yearly range of the needle about its mean position appeared to be established; but local influence seemed to have a large share in determining the nature of the annual curve.

(To be continued.)

SCIENTIFIC SERIALS

THE *Geological Magazine* for December (No. 102) opens with a description by Mr. James Cartro of a new genus and species of fossil crustacea from the Upper Greensand of Lyme Regis, which the author proposes to name *Orithopsis Bonneyi*. The

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fossil which appears to be nearly allied to *Necrocarcinus*, is figured on a plate accompanying the paper. Mr. C. Lapworth communicates a note on the Graptolitic black shales of the south of Scotland, in which he reiterates his opinion that there si but a single group of these shales, divisible, however, into three divisions—the Lower, Middle, and Upper Moffat shales. The first he regards as of Lower Llandeilo age, the second as equivalent to the Upper Llandeilo of Builth, and the third as Caradoc.—From Mr. S. Allport we have a valuable paper on the microscopic structure of the pitchstones and felsites of the island of Arran, in continuation of a former note published in the *Geological Magazine.* The number also contains a reprint of an interesting paper by Dr. Carpenter on the temperature and other physical conditions of inland seas, in their relation to geological inquiry.—Among the reports, &c., we find Mr. Woodward's sixth report on fossil crustacea, presented to the last meeting of the British Association. This contains a genealogical tree of the Crustacea.

Annalen der Chimie und Pharmacie, Nos. 11 and 12, 1872. —This double number contains a paper by Dr. Abeljanz on bichlorether, in which some of Lieben's results are called in question. The writer discusses chiefly the preparation of bichlorether, the action of pentachloride of phosphorus upon it, and its decomposition by water and by alkali.—In an essay on diphtalyl, Dr. Ador describes the preparation of this substance, through the action of finely-divided silver on dyphtalyl chloride. It has the formula $C_8\ H_4\ O_2$. It is insoluble in water, and soluble largely only in heated phenol and cold concentrated sulphuric acid. It fuses at 300°. The action of alkalies on dyphtalyl, dyphtalyl acid, its salts, and capability of oxidation, action of pentachloride of phosphorus and bromine on diphtalyl, and some of the by-products of preparation are among the points taken up.—J. Wislicenus communicates some observations on the so-called anhydrides of lactic acids. He finds that before all the water is evaporated from a solution of lactic acid, some anhydride is always present (with the acid), the quantity of which increases with the decrease of the water, and that, therefore, pure lactic acid of the formula $C_3\ H_6\ O_3$ does not exist. Further, that when lactic acid is kept in a dry atmosphere at ordinary temperature, there is formed not only the so-called anhydride, but also a lactide. —Th. Zincke and A. Franchimont describe nonylic acid, a colourless oily fluid, having the formula $C_9\ H_{18}\ O_2$, boiling about 253; specific gravity at 17·5° = 0·9065. It is little soluble in water, but distils slowly over with the vapour of boiling water. At a low temperature it solidifies to a crystalline mass, and it melts at + 10°.—Among the remaining papers in this number are lengthy monographs on some of the cyanogen derivatives of aceton, by Dr. F. Urech, and on the reduction products of silicic acid ether and some of its derivatives, by A. Ladenburg; also notes on the action of sodium on dibrombenzol, by Dr. Riese, and the constitution of sodium ethylate, by A. Laubenheimer.

Nos. 3 and 4 of the *Proceedings of the Swedish Academy of Sciences* for the present year, contains the proceedings of the Academy for March and April. The first paper is an account of an experimental investigation upon the electromotive and thermo-electric forces of certain metallic alloys in contact with copper, by M. A. F. Sundell. The alloys employed in these experiments consisted of bismuth and tin, and bismuth and antimony in various proportions, and of a white metal (*Nysilven*) the composition of which is not given. The action of bismuth is lessened in proportion to the amount of tin, and also by $\frac{1}{32}$ of antimony, but increased by $\frac{3}{32}$ of the latter metal. Iron is very low in the scale, which is similar for the electromotive and thermo-electric powers of the different metals and alloys.—Dr. C. Stäl communicates a synopsis of the European genera of Pentatornidæ in Latin, from which, curiously enough, the Cydnina are omitted.—Dr. H. D. J. Wallengrew furnishes a further contribution to the Lepidopterous fauna of South Africa, founded upon a small collection sent home by M. Akerberg, Swedish Consul at the Cape. His list, which includes species belonging to the groups from the butterflies to the Crambidæ, numbers seventy-one species, several of which are described as new, whilst descriptions and notes on synonymy are appended to many of the others. A new genus of Lycœnide butterflies, *Arrugia*, is proposed for *Zerythis basuta* Wall, *protumnus* Lin. The new species are all Geomitrina,—they are *Conchylia pactolaria*, *Camptogramma quaggaria*, *C. sylvicultrix*, *Macaria grimmia*, *M. getula*, *Tephrina nemorivaga*, *Panagra platyrhyncata*, *P. octomaculata and Mesotype textilis.*—A new species of mica called Manganophyll, from the iron and manganese mines of Paysberg in Wermland, is described by M. L. J. Igelström,—It contains 21·40 per cent. of protoxide of manganese, and varies from bronze to bright copper colour.—Prof. Angström enumerates and describes some mosses and Hepaticæ collected by Prof. N. J. Anderson, during the voyage of the frigate *Eugenie*, in 1851-53. The specimens are from Port Famine, from near Wollongong in Australia and from Honolulu. A great many of them are described as new species, and these belong to the genera *Gymnostornum*, *Orthotricum*, *Dicranum*, *Tortula*, *Bartramia*, *Gottschea*, and *pungermanina* (from Port Famine), *Thamnium* and *Lejeunia* (from Wollongong) *Hypnum*, *Plagiothecium*, *Omalia*, *Campylopus*, *Macromitrium*, *Fissideus*, *Jungennanina*, *Shagnœcetis*, *Lejeunia* and *Frullania*, (from Honolulu). M. C. A. F. Sädbour notices the nocturnal migratory habits of *Myodcs schisticolor* Lilljeb. The number concludes with a report by the secretary on the activity of the Academy during the year 1871-72.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, Dec. 13, 1872.—"Researches in Spectrum Analysis in connection with the Spectrum of the Sun."—No. I. By J. Norman Lockyer, F.R.S.

The author, after referring to the researches in which he has been engaged since January 1869 in conjunction with Dr. Frankland, refers to the evidence obtained by them as to the thickening and thinning of spectral lines by variations of pressure, and to the disappearance of certain lines when the method employed by them since 1869 is used. This method consists of throwing an image of the light-source to be examined on to the slit of the spectroscope.

It is pointed out that the phenomena observed are of the same nature as those already described by Stokes, W. A. Miller, Robinson, and Thalen, but that the application of this method enables them to be better studied, the metallic spectra being clearly separated from that of the gaseous medium through which the spark passes. Photographs of the spark, taken in air between zinc and cadmium and zinc and tin, accompany the paper, showing that when spectra of the vapours given off by electrodes are studied in this manner, the vapours close to the electrode give lines which disappear from the spectrum of the vapour at a greater distance from the electrode, so that there appear to be long and short lines in the spectrum.

Maps of the following elements have been mapped on this method:—Na, Li, Mg, Al, Mn, Co, Ni, Zn, Sr, Cd, Sn, Sb, Ba, and Pb, the lines being laid down from Thalen's maps, and the various characters and lengths of the lines shown.

In some cases the spectra of the metals, enclosed in tubes and subjected to a continually decreasing pressure, have been observed. In all these experiments the lines gradually disappear as the pressure is reduced, the *shortest lines disappearing first, and the longest lines remaining longest visible.*

Since it appeared that the purest and densest vapour alone gave the greatest number of lines, it became of interest to examine the spectra of compounds consisting of a metal combined with a non-metallic element. Experiments with chlorides are recorded. It was found in all cases that the difference between the spectrum of the chloride and the spectrum of the metal was, that under the same spark-conditions all the short lines were obliterated. Changing the spark-conditions, the final result was, that only the very longest lines in the spectrum of the metallic vapour remained. It was observed that in the case of elements with low atomic weights, combined with one equivalent of chlorine, the numbers of lines which remain in the chloride is large, 60 per cent. *e.g.*, in the case of Li, and 40 per cent. in the case of Na; while in the case of elements with greater atomic weights, combined with two equivalents of chlorine, a much smaller number of lines remain—8 per cent. in the case of barium, and 3 per cent. in the case of Pb.

The application of these observations to the solar spectrum, to elucidate which they were undertaken, is then given.

It is well known that all the known lines of the metallic elements on the solar atmosphere are not reversed. The author states what Kirchhoff and Angström have written on this subject, and what substances, according to each, exist in the solar atmosphere. He next announces the discovery that, with no exception whatever, *the lines which are reversed are the longest lins.* With this additional key he does not hesitate to add, on

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